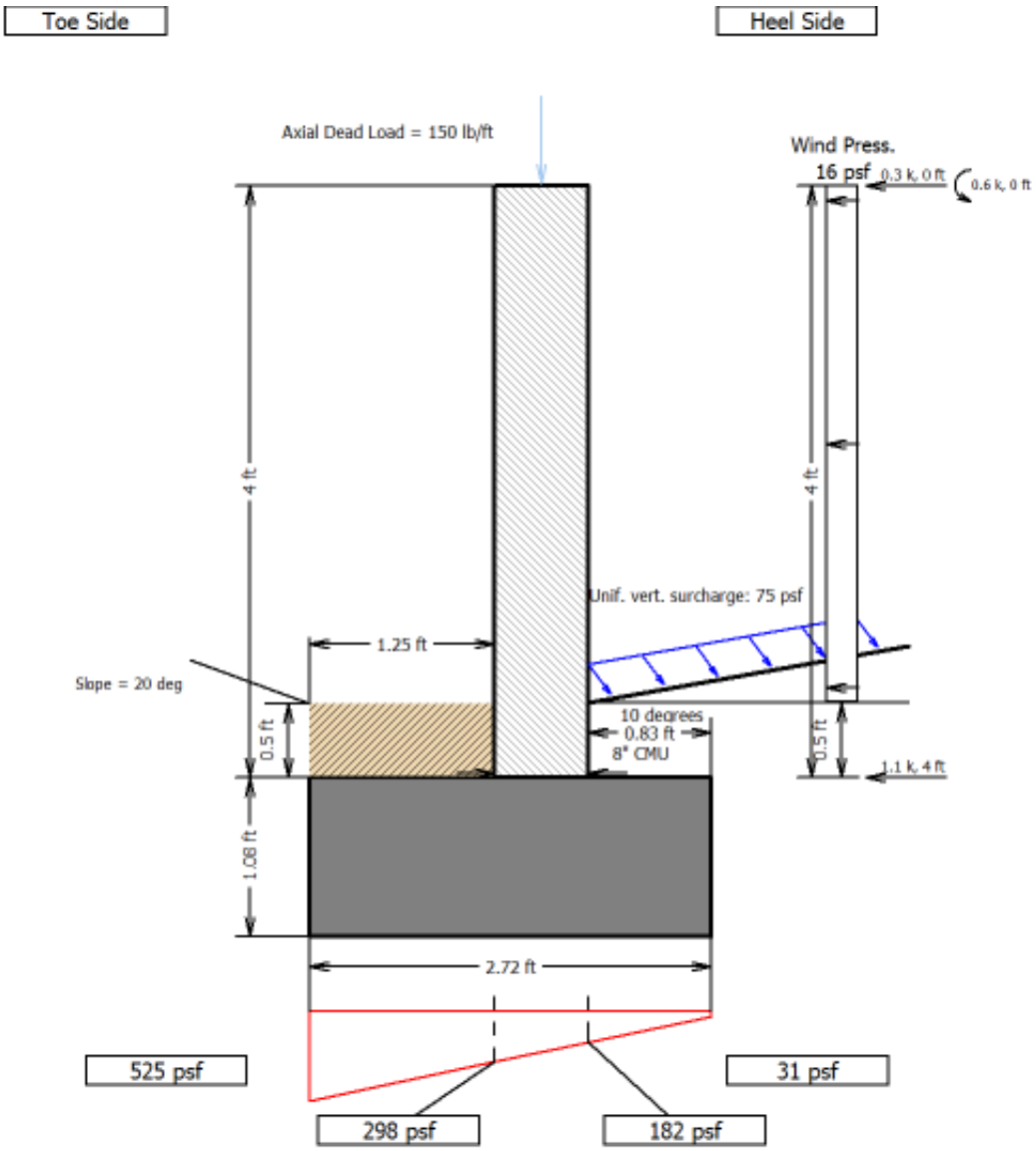
Cantilever or Restrained Retaining Wall Design Calculations

Organization: **F.E.C.**
Project Name: **Ex 4 Fence Wall**
Design by: **LAA**
Job #:
Date: **7/5/2016**

Codes used: **2012 + 2015 IBC, ACI 318-14, ACI 530-11**



NOTES:
1. Refer to Table 19.2.1.1, ACI 318-14, for compressive strength requirements.
2. Refer to Table 19.3.1.1, ACI 318-14, for exposure categories and classes.
3. Refer to Table 19.3.2.1, ACI 318-14, for mixture requirements.

Input Parameters

General Data	
Number of stem sections	1
Top Restrained	No
Concrete Unit Weight	150 pcf
Bar Strength (Fy)	60.00 ksi
Parapet Height	3.50 ft
Wind Pressure	16.00 psf
Groundwater (from top)	4.00 ft
Full Ht. Distr. Loading	0.000 kips/ft
From Un. Vert. Surch.	0.031 kips/ft

Backfill Soils	
Müller-Breslau Method	
Soil Friction Angle	22.0 degrees
Soil-Wall Friction Angle	16.5 degrees
Backfill Slope Angle	10.0 degrees
Backwall Inclination Ang.	82.5 degrees
Soil Cohesion	50.00 psf
Soil/Rock Unit Weight	115.0 pcf
Allow Bear. Capacity	1500 psf
Uniform Vert. Surcharge	75.0 psf
Wall Height (Stem+Foot.)	5.08 ft
	2013 Mikola/Sitar
Seismic Kh	0.00 g
Overconsol. Ratio (OCR)	1.00

Passive Soils	
Soil Friction Angle	22.0 degrees
Soil-Wall Friction Angle	-11.0 degrees
Passive Slope Angle	20.0 degrees
Ftng/Keyway Inclin. Ang.	90.0 degrees
Soil Cohesion	50.00 psf
Soil/Rock Unit Weight	108.00 pcf
Ignore Passive Ht.	0.75 ft
Passive F.S.	1.50
F.S. on Sliding Fri. Coeff.	1.50

Global Stability of a Vertical Cut

Stem Section Design	
Stem Type	Masonry
Masonry Strength (f'm)	2.20 ksi
Wall Height	4.00 ft
Section Size	8 in
Axial Live Load	0 lb/ft
Axial Dead Load	150 lb/ft
Reinforcement - Vertical	
Vert. Bar Size Heel Side	#4
Vert. Spacing Heel Side	16 in
Bar Cover	3.25 in
Reinforcement - Horizontal	
Horiz. Bar Size Heel Side	#4
Horiz. Spacing Heel Side	16 in

Footing Dimensions	
Heel Width	0.83 ft
Stem Width Bottom	0.64 ft
Toe Width	1.25 ft
Footing Thickness	1.08 ft
Tot. Footing Width	2.72 ft
Footing Soil Cover	0.50 ft
Concrete Strength (f'c)	3.50 ksi
Sliding Restraint at the Toe	No

Additional Loads and Moments

Lateral Loads	Dist.from top, ft	Force, kips
Slope creep	4.00	1.10
Guardrail Load	0.00	0.30

Factored Moments	Dist.from top, ft	Moment, ft-kips
Moment 1	0.00	0.60

Base Shear Keyway - Not Used

Heel Reinforcement	
Bar Size	#4
Bar Spacing	8.0 in
Bar Cover	2.00 in

Toe Reinforcement	
Bar Size	#4
Bar Spacing	8.0 in
Bar Cover	3.00 in

Shrinkage and Temperature Reinforcement	
S & T Bar Size	#4
Nr of Bars Bottom	3
Nr of Bars Top	3

Footing Settlement	
Poisson's ratio	0.35
Elastic Soil Modulus	700000 psf
Vert. Subgrade Modulus	100 ton/ft^3

Analysis and Design Results

Earth Pressures	
Active Earth Pressure Coeff.	0.413
Passive Resistance Coeff.	6.347
Earth Press. - Horiz. Comp.	132.76 lb
Earth Press. - Vert. Comp.	29.21 lb
Uniform Surcharge Comp.	53.53 lb
Passive Resist. Comp.	124.88 lb
Opposing Keyway Press. (1807.2.1)	0.00 lb
Equiv. Fluid Pressure Active	47.5 psf/ft
Equiv. Fluid Resistance Passive	486.6 psf/ft
Seismic Pressure Component	0.00 lb
Sliding Friction Coefficient	0.27

Retaining Wall Stability	
Overturning F.S. Results	
Overturning Moment	275.49 lb-ft
Resisting Moment	1775.93 lb-ft
F.S. against Overturning	6.45
Sliding F.S. Results	
Sliding Force	186.29 lb
Resisting Force	498.40 lb
F.S. against Sliding	2.68

Footing Pressures	
Resultant Loc. from Toe	1.27 ft
Resultant in middle third	
Toe Bearing Pressure	525 psf
Heel Bearing Pressure	31 psf

Surcharge Loads	
Strip Load Does Not Apply	
Line Load Does Not Apply	
Point Load Does Not Apply	
Total Lateral Thrust	0.00 lb/ft
Total Resultant from Stem Top	0.00 ft

Footing Settlement	
Average Bearing Pressure	259 psf
Distortion Settlement	0.02 in
Consolidation Settlement	0.07 in
Total Settlement	0.09 in
Settlement OK	

Stronger soil over weaker layer or vice-versa are not considered

Stem Section	
Flexure	
Moment Demand (Mu)	2251 lb-ft
Moment Capacity (PhiMn)	2641 lb-ft
Reinforcement - Vertical	
Rho Min. Vertical	0.0015
Rho Max. Vertical	0.0100
Actual Rho Vertical	0.0016
Vert. Heel Side Steel Bar Used	#4 @ 16.0
Area of Steel - Vertical	0.15 in^2
Reinforcement - Horizontal	
Rho Min. Horizontal	0.0015
Rho Max. Horizontal	0.0100
Actual Rho Horizontal	0.0016
Horiz. Heel Side Steel Bar Used	#4 @ 16.0
Area of Steel - Horizontal	0.15 in^2
Shear	
Shear Demand (Vu)	523 lb
Shear Capacity (PhiVc)	7853 lb

Heel Design	
Flexure	
Moment Demand (Mu)	69 lb-ft
Moment Capacity (PhiMn)	14143 lb-ft
Rho Min. Heel	0.0018
Rho Max. Heel	0.0181
Actual Rho Used	0.0023
Heel Steel Used	#4 @ 8.0
Heel Area of Steel	0.30 in^2
Shear	
Shear Demand (Vu)	305 lb
Shear Capacity (PhiVn)	11405 lb

Toe Design	
Flexure	
Moment Demand (Mu)	418 lb-ft
Moment Capacity (PhiMn)	12793 lb-ft
Rho Min. Toe	0.0018
Rho Max. Toe	0.0181
Actual Rho Used	0.0026
Toe Steel Used	#4 @ 8.0
Toe Area of Steel	0.30 in^2
Shear	
Shear Demand (Vu)	370 lb
Shear Capacity (PhiVn)	10340 lb

Base Shear Keyway - Not Used

Bar Development	
Heel into toe	15.8 in
Toe into heel	12.2 in
Stem into footing	8.9 in

Stem - Top of Footing Shear Key	
Bearing Stress (10% f'c)	350 psi
Pure Shear Stress	101 psi

Shrinkage and Temperature	
Max. spacing is 18.0 in	
Bar Spacing Bottom	9.1 in
Bar Spacing Top	8.5 in

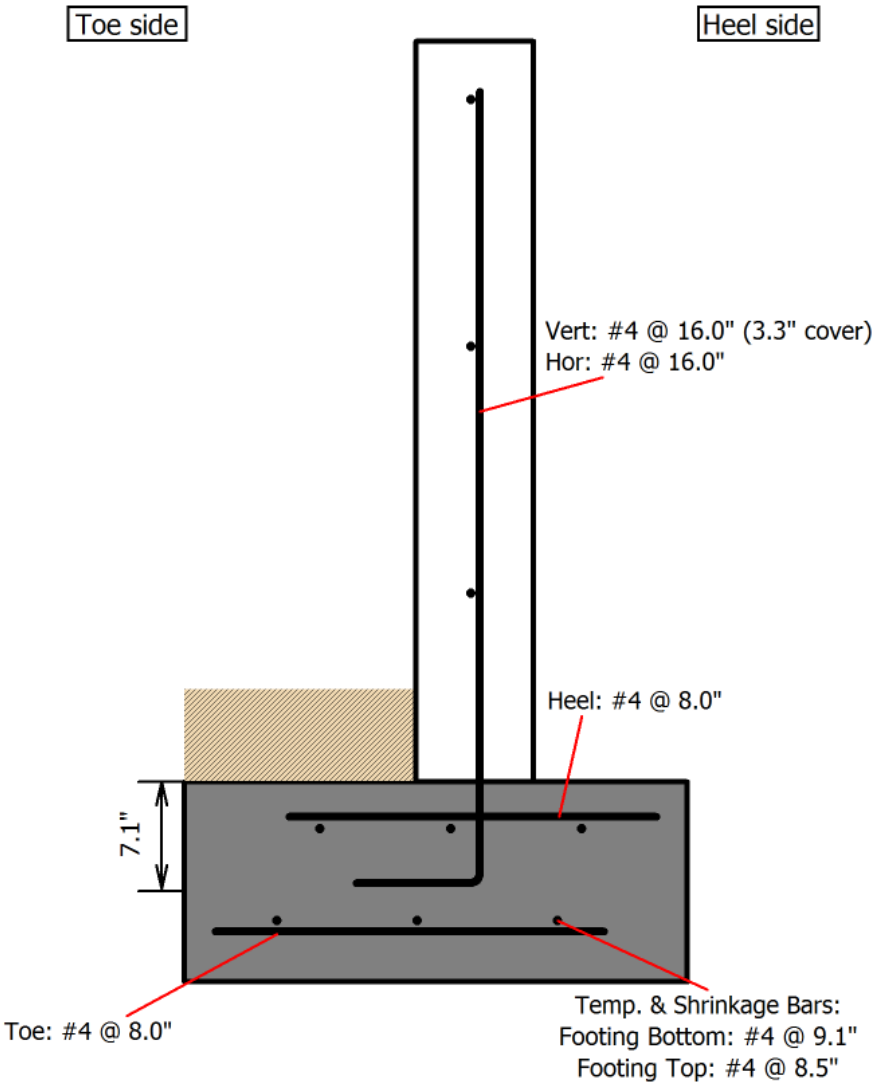
Global Stability	
Req. Cohesion for Toe Circle	132.1 psf
Req. Cohesion for Base Circle	96.5 psf

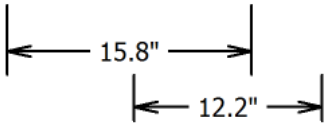
Only valid for Cohesive Soils, not a comprehensive Slope Stability Analysis

Stem Wall Deflection	
Deflection Req. for Active State	0.061 in
Approx. top of Stem Deflection	0.019 in

Deflection OK (< 0.20)

Design for K between Active and At Rest values





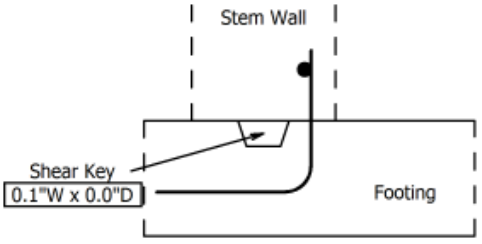
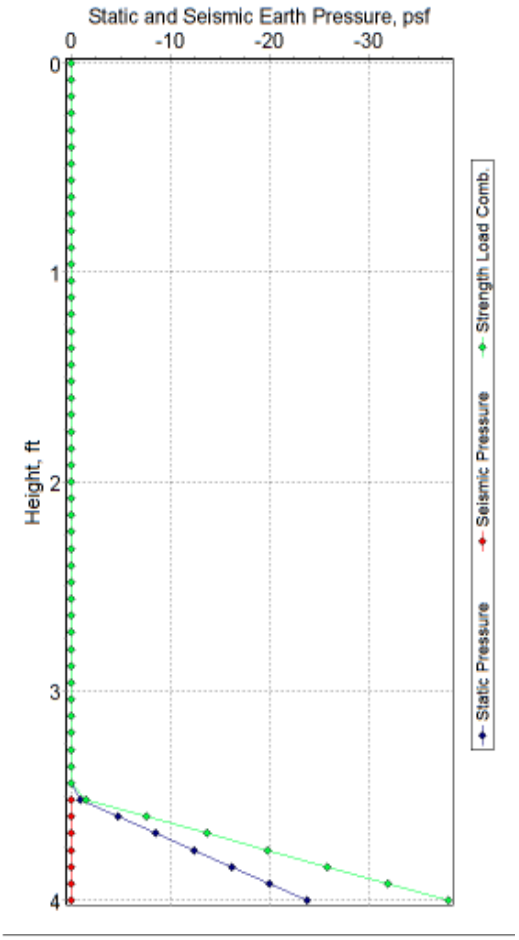
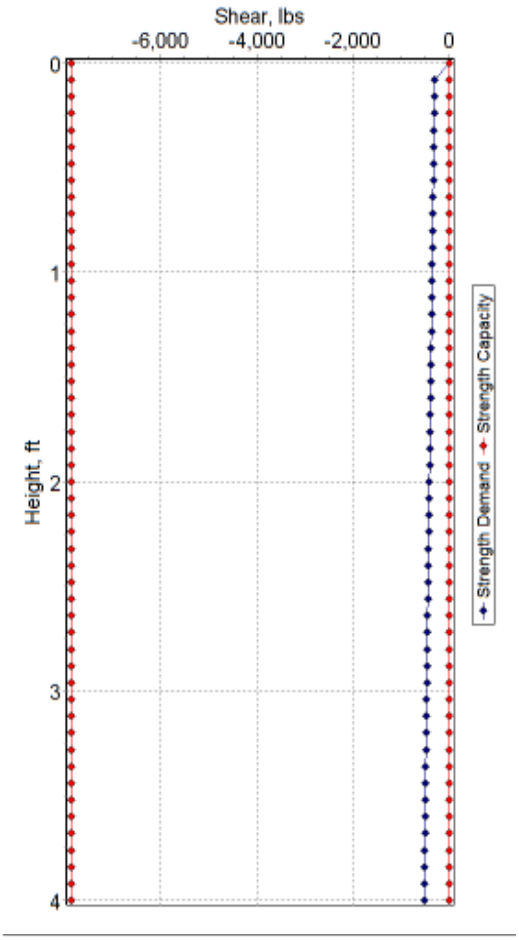


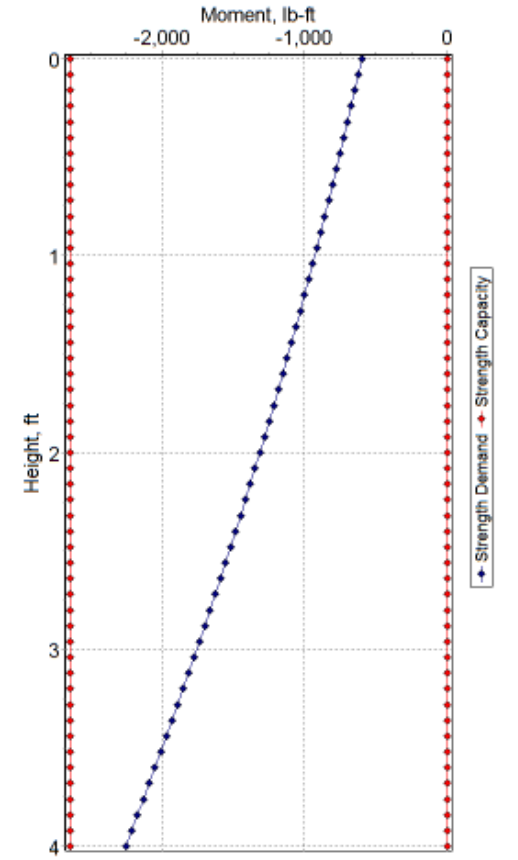
Table of Test Results - Stem Forces

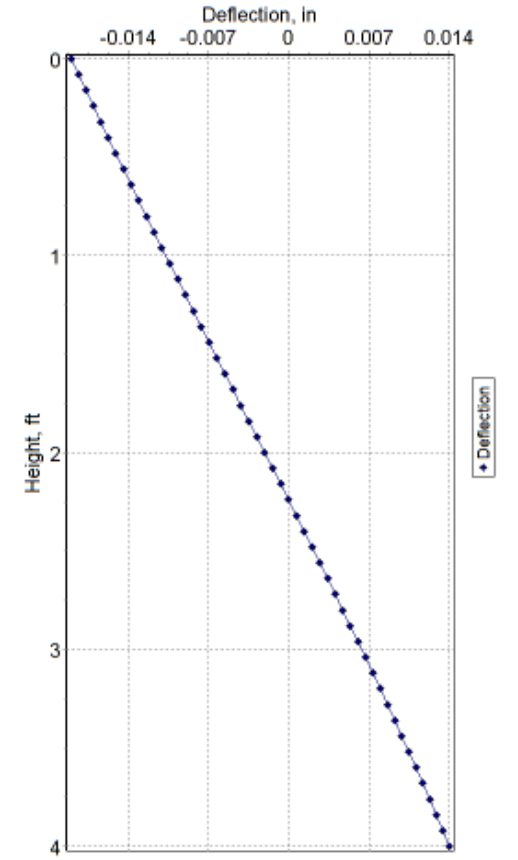
Node #	Stem Ht, inch	Soil Press, psf	Vu, lb	phiVn, lb	Mu, lb-ft	phiMn, lb-ft	Slope/Rot, deg	Deflection, in
1	0.0	0.0	0.0	-7852.6	-600.0	-2640.6	0.038	-0.019
2	1.0	0.0	-304.5	-7852.6	-624.2	-2640.6	0.037	-0.018
3	1.9	0.0	-309.1	-7852.6	-648.7	-2640.6	0.037	-0.018
4	2.9	0.0	-313.6	-7852.6	-673.6	-2640.6	0.037	-0.017
5	3.8	0.0	-318.1	-7852.6	-698.9	-2640.6	0.036	-0.016
6	4.8	0.0	-322.6	-7852.6	-724.5	-2640.6	0.036	-0.016
7	5.8	0.0	-327.2	-7852.6	-750.5	-2640.6	0.035	-0.015
8	6.7	0.0	-331.7	-7852.6	-776.9	-2640.6	0.035	-0.014
9	7.7	0.0	-336.2	-7852.6	-803.6	-2640.6	0.034	-0.014
10	8.6	0.0	-340.8	-7852.6	-830.7	-2640.6	0.034	-0.013
11	9.6	0.0	-345.3	-7852.6	-858.1	-2640.6	0.034	-0.012
12	10.6	0.0	-349.8	-7852.6	-885.9	-2640.6	0.033	-0.012
13	11.5	0.0	-354.3	-7852.6	-914.1	-2640.6	0.033	-0.011
14	12.5	0.0	-358.9	-7852.6	-942.6	-2640.6	0.032	-0.010
15	13.4	0.0	-363.4	-7852.6	-971.5	-2640.6	0.032	-0.010
16	14.4	0.0	-367.9	-7852.6	-1000.8	-2640.6	0.031	-0.009
17	15.4	0.0	-372.5	-7852.6	-1030.4	-2640.6	0.030	-0.008
18	16.3	0.0	-377.0	-7852.6	-1060.4	-2640.6	0.030	-0.008
19	17.3	0.0	-381.5	-7852.6	-1090.7	-2640.6	0.029	-0.007
20	18.2	0.0	-386.0	-7852.6	-1121.4	-2640.6	0.029	-0.006
21	19.2	0.0	-390.6	-7852.6	-1152.5	-2640.6	0.028	-0.006
22	20.2	0.0	-395.1	-7852.6	-1183.9	-2640.6	0.027	-0.005
23	21.1	0.0	-399.6	-7852.6	-1215.7	-2640.6	0.027	-0.004
24	22.1	0.0	-404.2	-7852.6	-1247.8	-2640.6	0.026	-0.003
25	23.0	0.0	-408.7	-7852.6	-1280.3	-2640.6	0.025	-0.003
26	24.0	0.0	-413.2	-7852.6	-1313.2	-2640.6	0.025	-0.002
27	25.0	0.0	-417.7	-7852.6	-1346.5	-2640.6	0.024	-0.001
28	25.9	0.0	-422.3	-7852.6	-1380.1	-2640.6	0.023	-0.001
29	26.9	0.0	-426.8	-7852.6	-1414.0	-2640.6	0.022	0.000
30	27.8	0.0	-431.3	-7852.6	-1448.3	-2640.6	0.021	0.001
31	28.8	0.0	-435.9	-7852.6	-1483.0	-2640.6	0.021	0.001
32	29.8	0.0	-440.4	-7852.6	-1518.1	-2640.6	0.020	0.002
33	30.7	0.0	-444.9	-7852.6	-1553.5	-2640.6	0.019	0.003
34	31.7	0.0	-449.4	-7852.6	-1589.3	-2640.6	0.018	0.003
35	32.6	0.0	-454.0	-7852.6	-1625.4	-2640.6	0.017	0.004
36	33.6	0.0	-458.5	-7852.6	-1661.9	-2640.6	0.016	0.005
37	34.6	0.0	-463.0	-7852.6	-1698.8	-2640.6	0.015	0.005
38	35.5	0.0	-467.6	-7852.6	-1736.0	-2640.6	0.014	0.006
39	36.5	0.0	-472.1	-7852.6	-1773.6	-2640.6	0.013	0.007
40	37.4	0.0	-476.6	-7852.6	-1811.5	-2640.6	0.012	0.007
41	38.4	0.0	-481.1	-7852.6	-1849.8	-2640.6	0.011	0.008
42	39.4	0.0	-485.7	-7852.6	-1888.5	-2640.6	0.010	0.009
43	40.3	0.0	-490.2	-7852.6	-1927.5	-2640.6	0.009	0.009
44	41.3	0.0	-494.7	-7852.6	-1966.9	-2640.6	0.008	0.010
45	42.2	-1.5	-498.8	-7852.6	-2006.7	-2640.6	0.007	0.010
46	43.2	-7.6	-501.6	-7852.6	-2046.7	-2640.6	0.006	0.011
47	44.2	-13.7	-504.9	-7852.6	-2087.0	-2640.6	0.005	0.012
48	45.1	-19.8	-508.8	-7852.6	-2127.5	-2640.6	0.004	0.012
49	46.1	-25.9	-513.1	-7852.6	-2168.4	-2640.6	0.002	0.013
50	47.0	-31.9	-517.9	-7852.6	-2209.6	-2640.6	0.001	0.013
51	48.0	-38.0	-523.1	-7852.6	-2251.2	-2640.6	0.000	0.014

Stem Forces

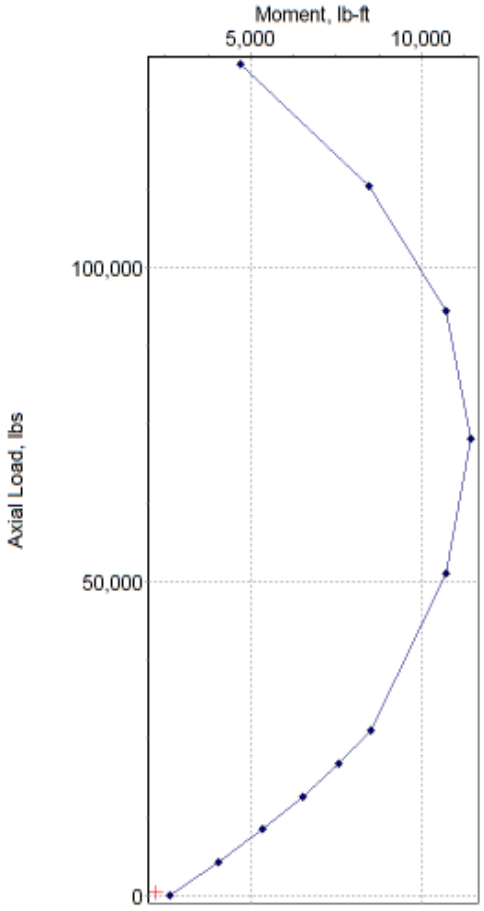

Static and Seismic Earth Pressure, psf
0
-10
-20
-30
Height, ft
0
1
2
3
4
Static Pressure
Seismic Pressure
Strength Load Comb.


Shear, lbs
-6,000
-4,000
-2,000
0
Height, ft
0
1
2
3
4
Strength Demand
Strength Capacity


Moment, lb-ft
-2,000
-1,000
0
Height, ft
0
1
2
3
4
Strength Demand
Strength Capacity


Deflection, in
-0.014
-0.007
0
0.007
0.014
Height, ft
0
1
2
3
4
Deflection

P-M Diagrams



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